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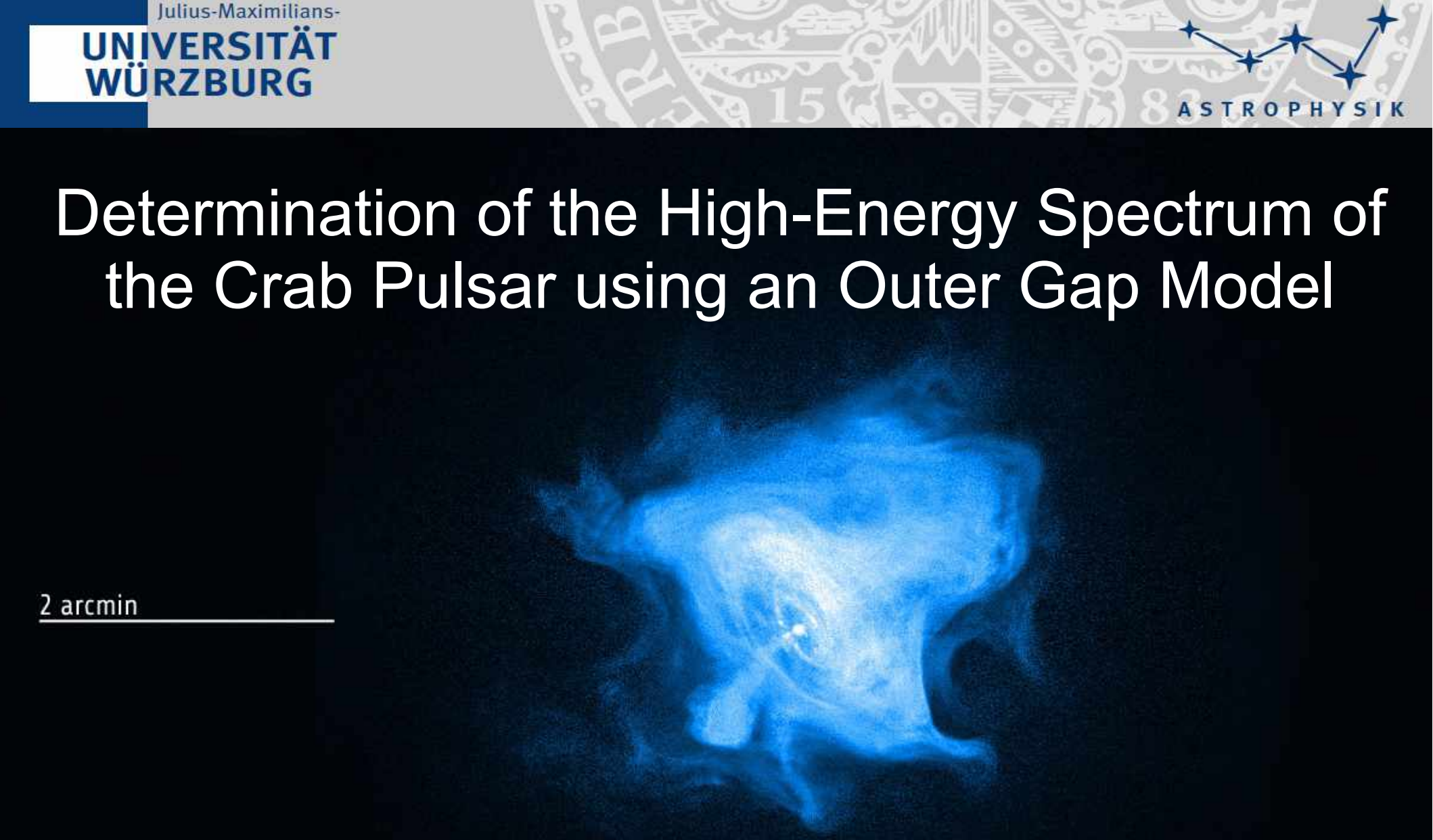
ASTROPHYSIK

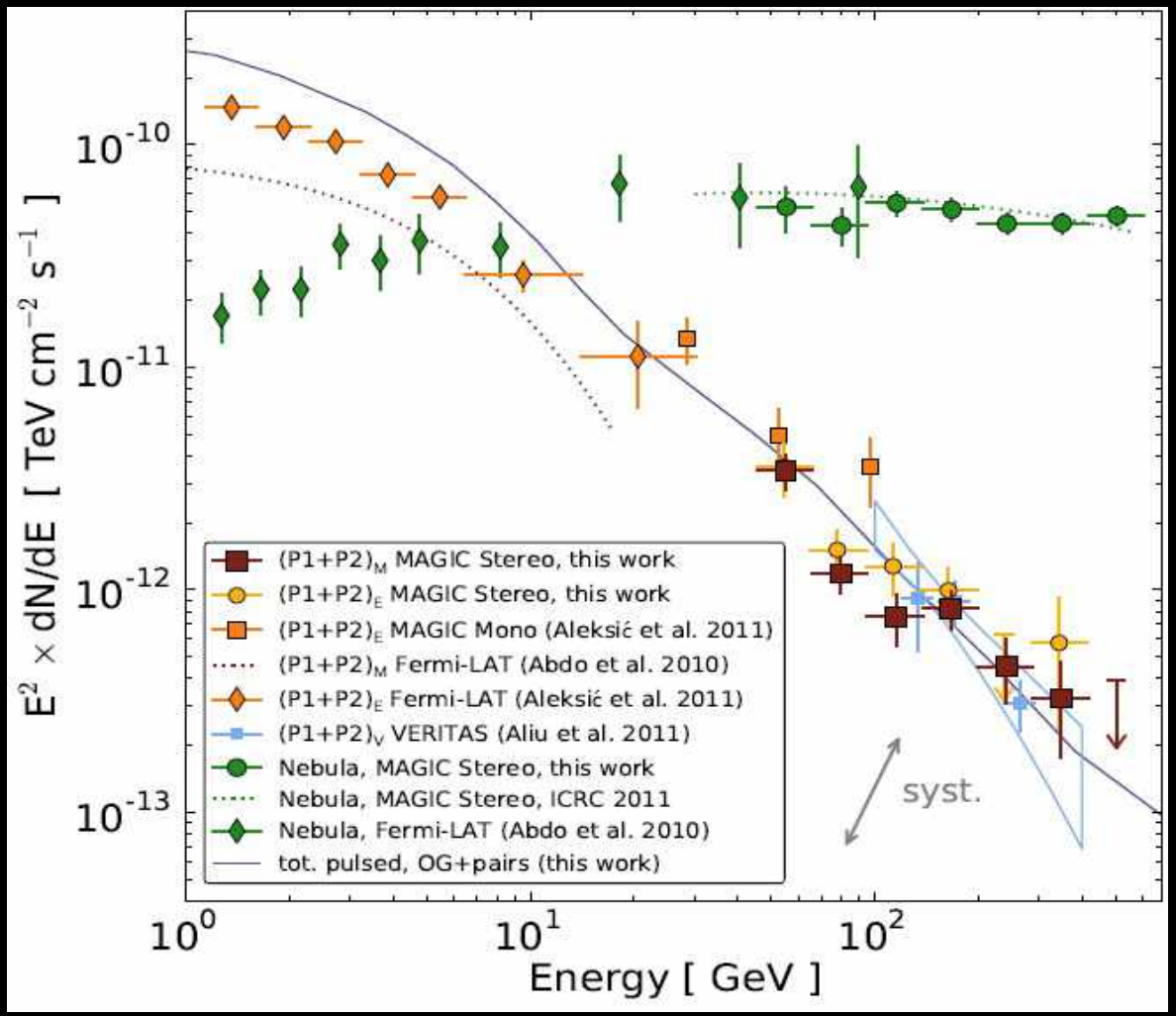
Determination of the High-Energy Spectrum of the Crab Pulsar using an Outer Gap Model



Talk by Christoph Wendel at the AG-Tagung 2013

Image credit: NASA/CXC/SAO/F.Seward et al

Motivation



Aleksić et al, 2012

- 2008, MAGIC: detection above 25GeV
- 2010, Fermi-LAT: spectrum up to 20GeV
- 2012, MAGIC: registration up to 400GeV

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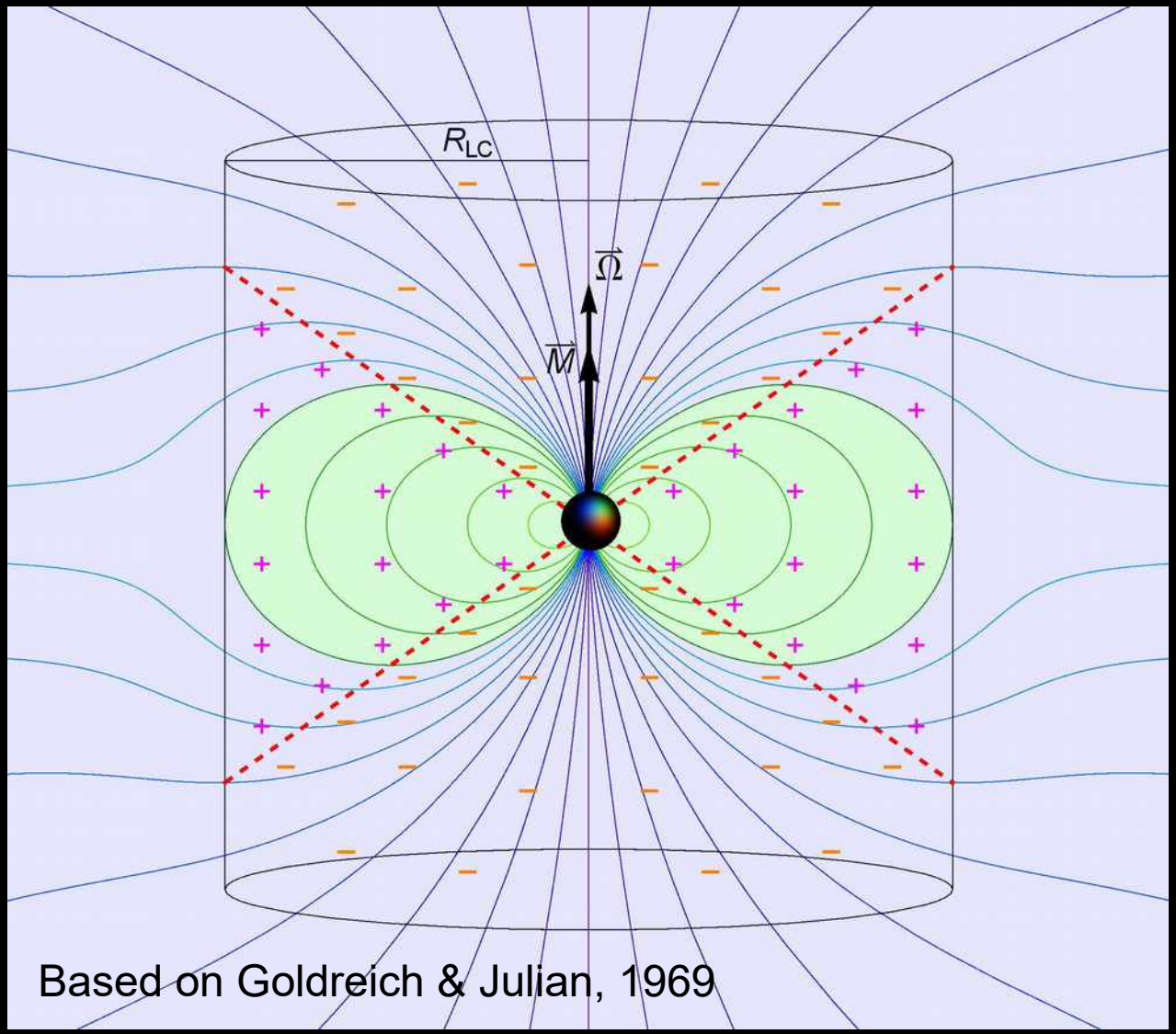
theoretical challenge

Standard-model of pulsar-magnetospheres



Based on Goldreich & Julian, 1969

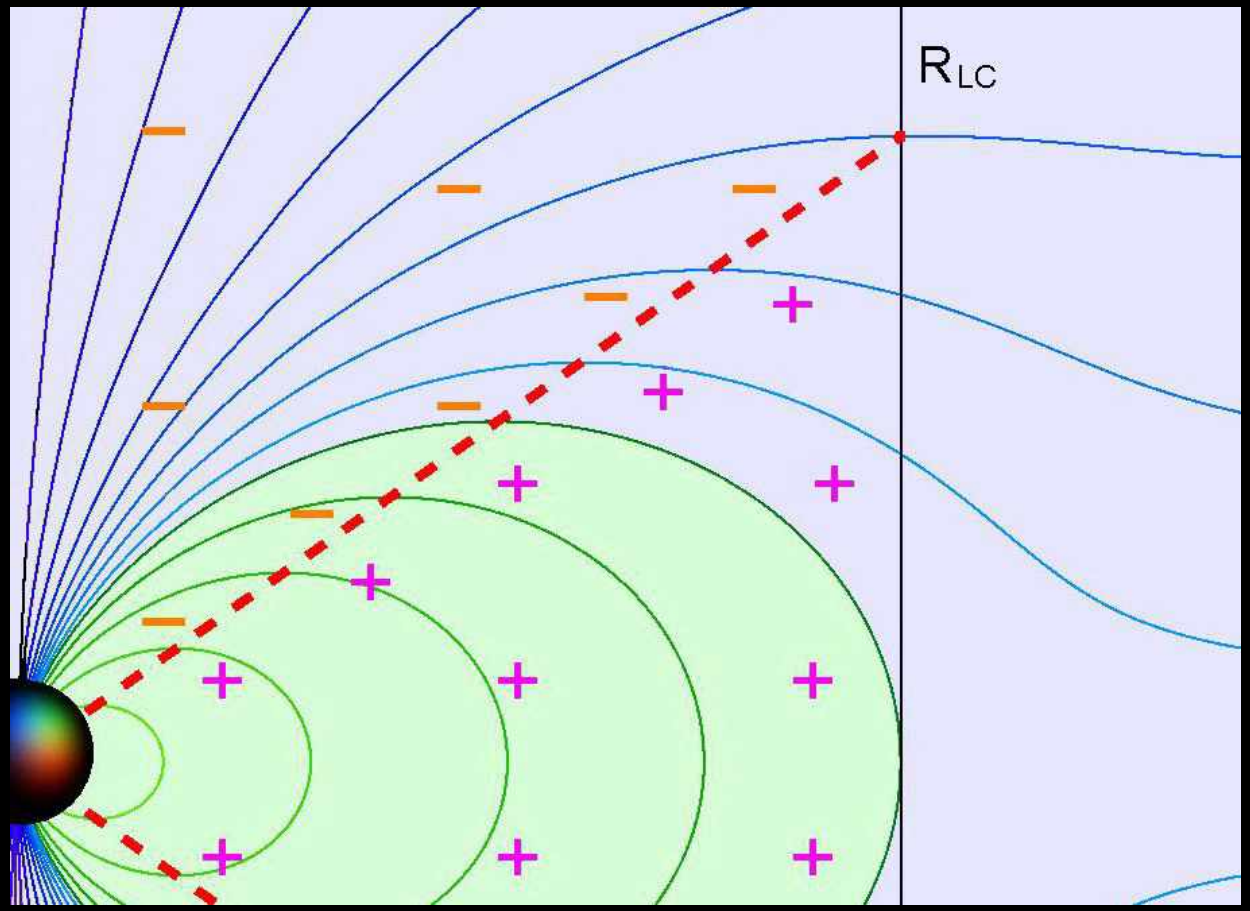
outflow of e^+, e^-

$$\vec{E}\cdot\vec{B}=0,\quad \vec{E}\times\vec{B}\neq 0$$

$$\rho_{GJ}(\vec{r})\approx\frac{\vec{\Omega}\cdot\vec{B}(\vec{r})}{2\pi c}$$

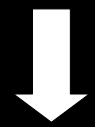
- null-charge-surface
- $R_{LC}=c/\Omega$
- closed field-lines
- open field-lines

Outer Gap model



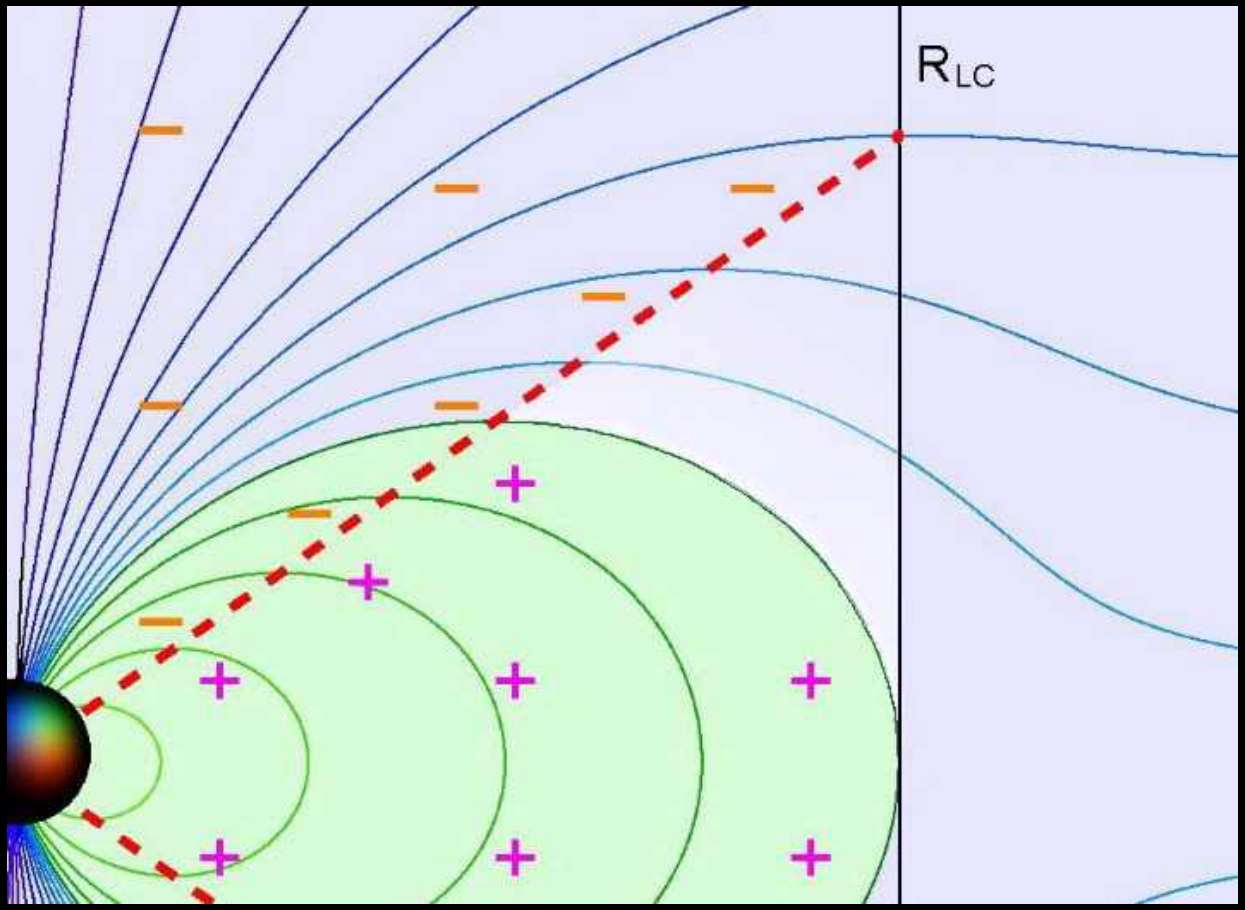
Based on Goldreich & Julian, 1969
and Cheng, Ho & Ruderman, 1986

current-system on open field-lines



outflow of space-charge

Outer Gap model



Based on Goldreich & Julian, 1969
and Cheng, Ho & Ruderman, 1986

current-system on open field-lines

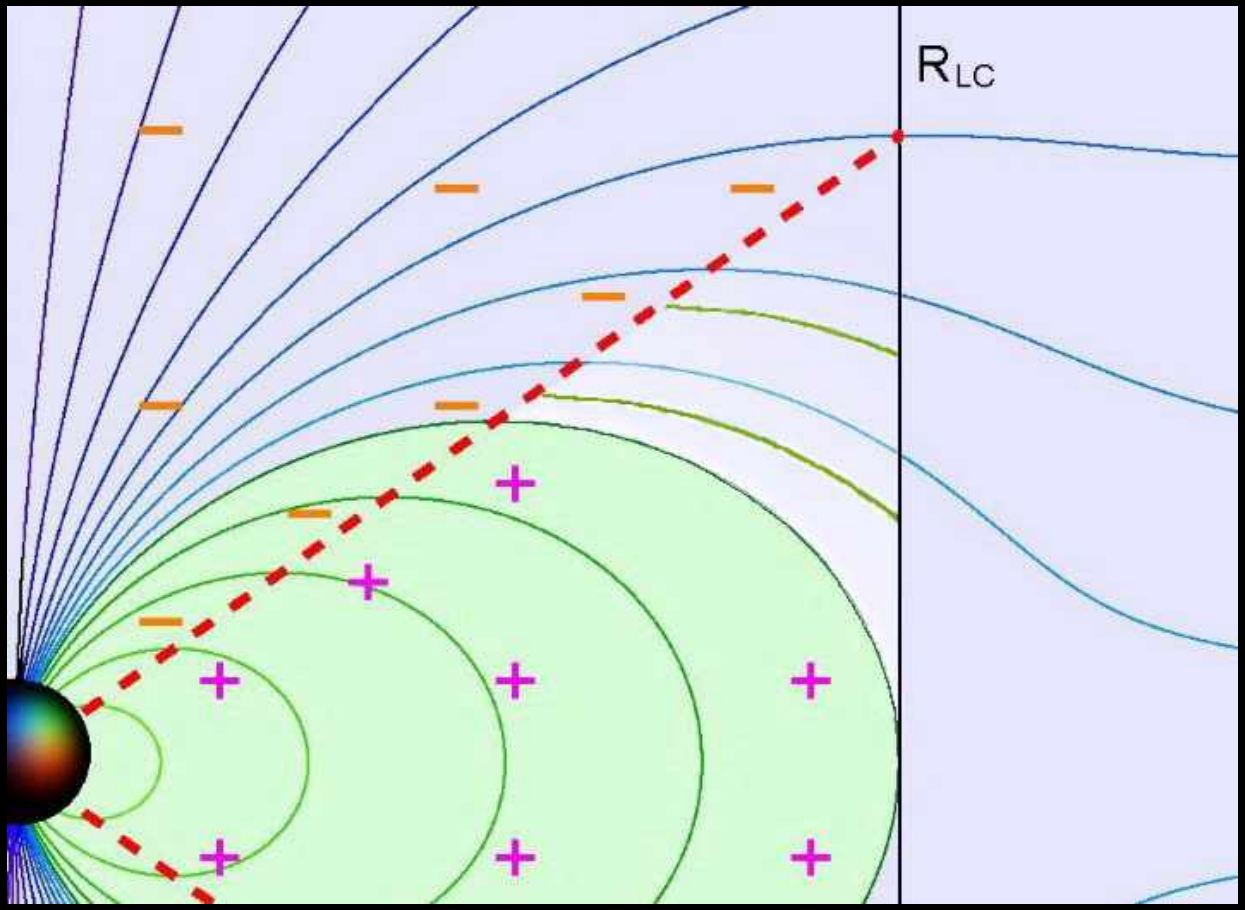
↓

outflow of space-charge

↓

evacuation

Outer Gap model



Based on Goldreich & Julian, 1969
and Cheng, Ho & Ruderman, 1986

current-system on open field-lines

↓

outflow of space-charge

↓

evacuation

↓

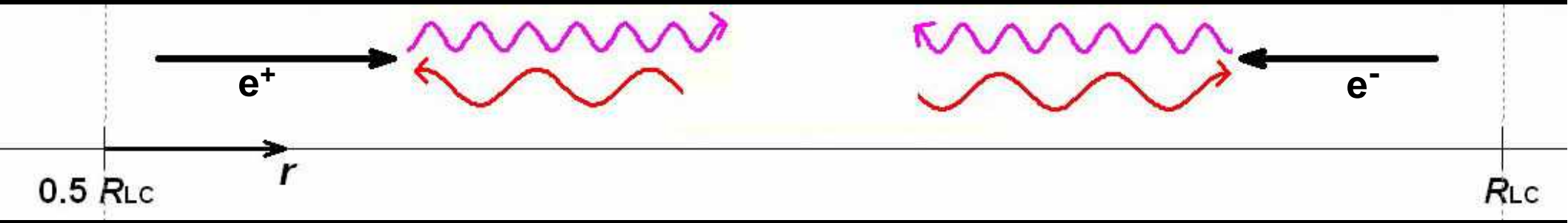
formation of Outer Gap

$\vec{E} \cdot \vec{B} \neq 0$

Assumptions

- 1-D model
- inner / outer boundary of gap $0.5\,R_{LC}$ / R_{LC}
- particles' number-density N
- dipolar magnetic field ➡ radius of curvature $R_c(r)$
  ➡ curvature-radiation $P_{curv}(r)$
- accelerating electric field $E_{acc}(r)$ ➡ $P_{acc}(r)$
- $P_{acc}(r) = P_{gain} = P_{loss} = P_{curv}(r)$ ➡ $\gamma(r)$

Assumptions



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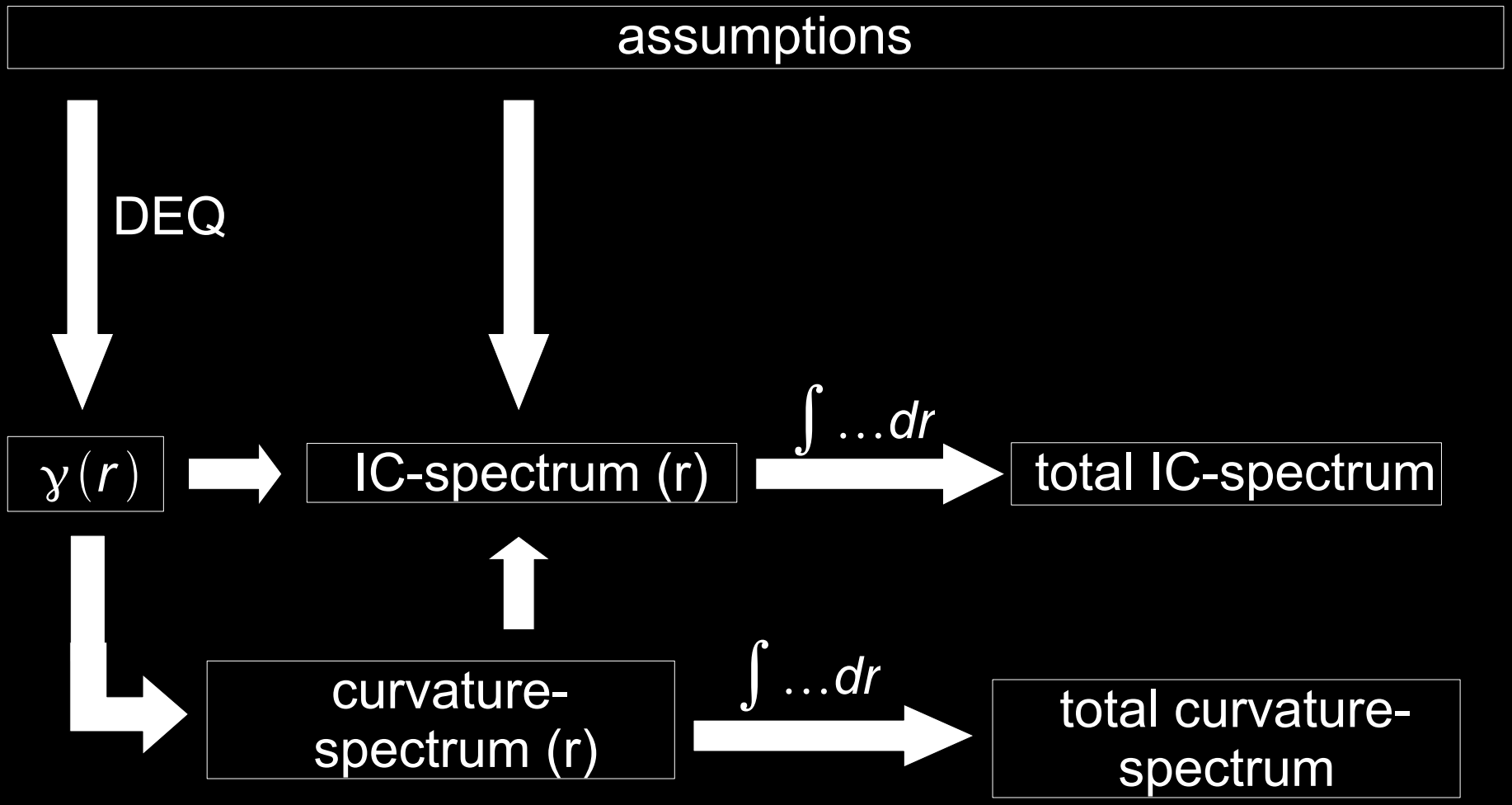
- $P_{acc}(r) = P_{gain} = P_{loss} = P_{curv}(r)$ ➡ $\gamma(r)$
- inverse Compton-scattering (head-on) $P_{IC}(r)$

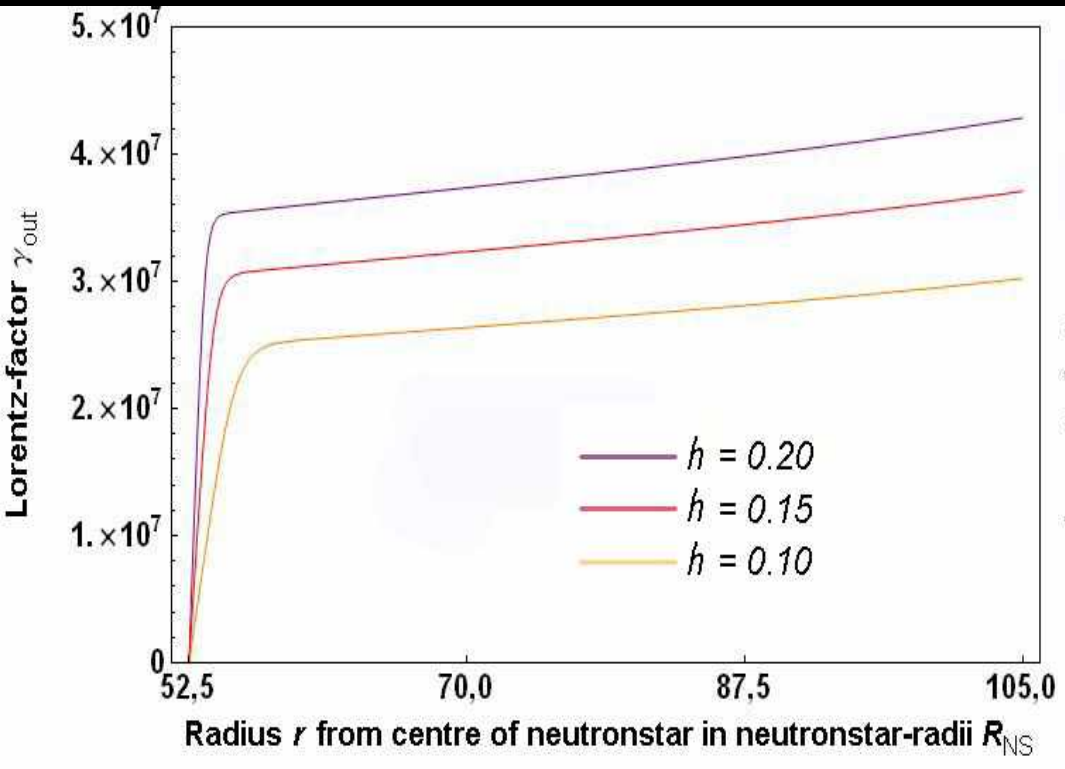
Numerical method
using Wolfram *Mathematica*



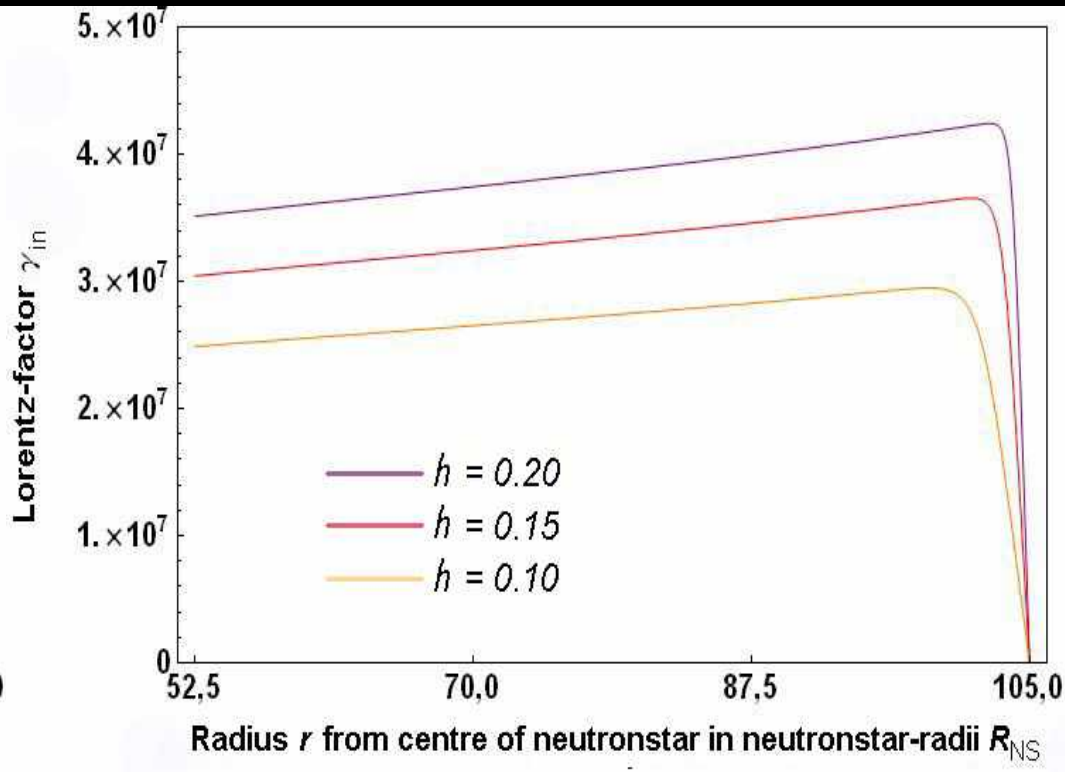
Results

$\gamma(r)$

outward moving e^+



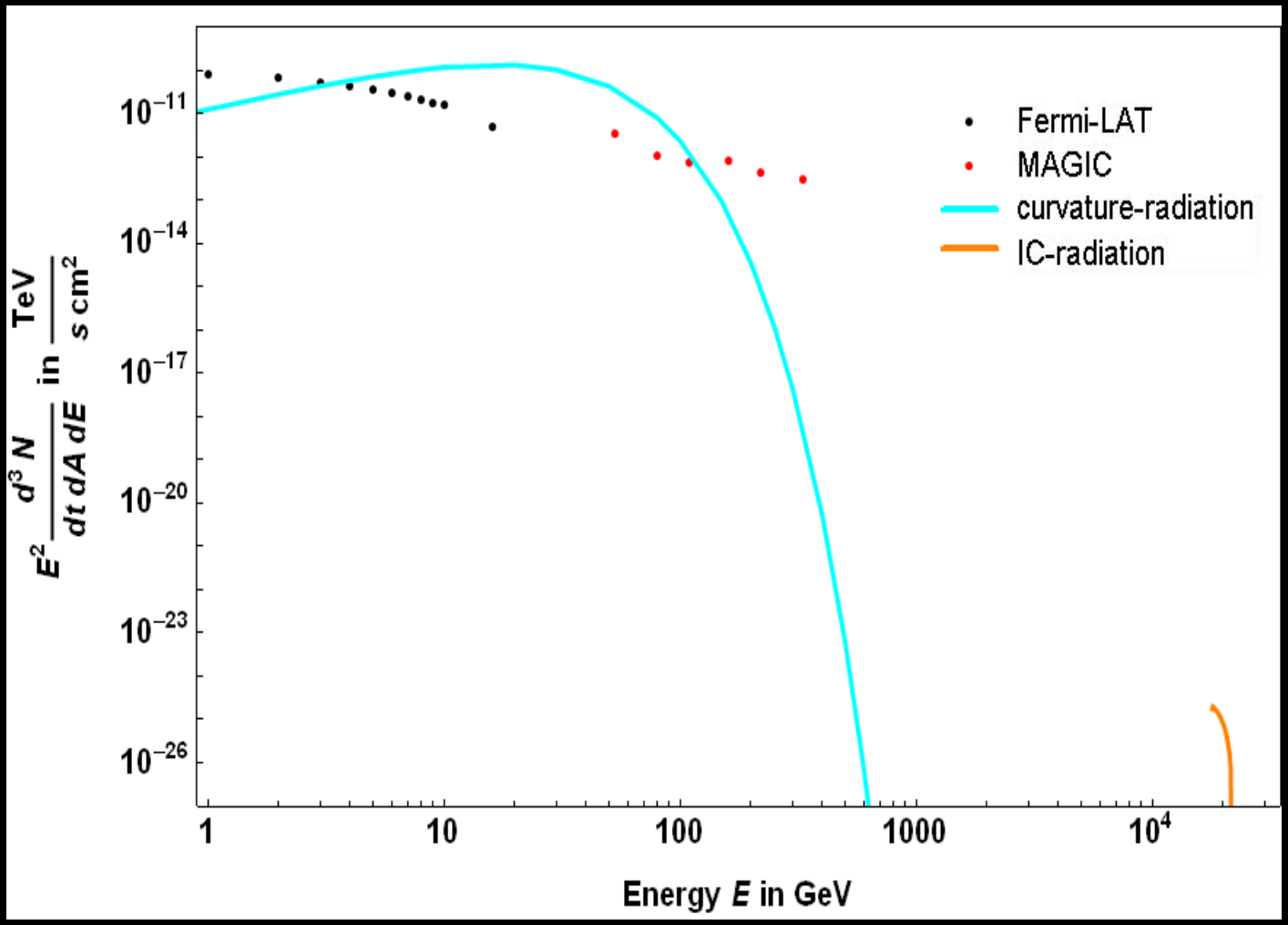
inward moving e^-



- short acceleration zone
- wide emission zone
- maximum $\gamma \approx 4 \cdot 10^7$

Results

Spectra



spectrum for

$N = 10^{-4} \cdot \rho_{GJ} / e$

improvements:

- adjustment of number-density
- pair-production
- IC-Thomson-scattering
- 2-D model